Risk Assessment Modeling Approach for the Prioritization Of Oil Removal Operations from Sunken Wrecks

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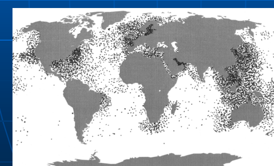
Great need for assessment of environmental risks from shipwrecks

- Worldwide over 8,500 potentially polluting shipwrecks
- 1,500 tank ships and 7,000 non-tank vessels (>400 GRT)
- Estimated 2 – 20 million tonnes of oil on board
- 75% of these wrecks are from WWII.



Source: Environmental Research Consulting Wreck Databases

Wreck removal convention 2007

The Convention seeks to lay down a uniform set of rules for dealing with a wreck (incl. cargo & bunkers) and its removal. In this respect the Convention reflects current non-convention practice but with the very significant introduction of compulsory insurance and the right of action directly against that insurer

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Removal of oil from individual leaking wrecks = REACTIVE STRATEGY

Vessel name	Year	Country	Quantity	Cargo	Water depth
			tonnes		Metres
Alessandro Primo	1991	Italy		Dichlorethane/ Acrylonitrile	110
Ievoli Sun	2001	France	4000	Styrene/bunkers	95
Osung no.3	1998	Korea	160	bunkers	70
Ice Prince	2009	UK	350	Marine diesel	60
Haven	2008	Italy		bunkers	65
Bow Mariner	2004	USA		Methanol/Bunkers	80
Solar 1	2006	Philippines	2000	oil	630
Tanio (bow)	1980	UK/France	< 5000	Heavy fuel	90
Erika	1999	UK/France	11,100	Fuel	100-130
Yuil no.1	1998	Korea		Fuel	70
Sea Diamond	2007	Greece	100-150	Fuel	150
Samho Brother	2009	Taiwan		Benzeen/bunkers	72

PROACTIVE STRATEGY

Assess and remove oil from potentially-polluting wrecks *before* leakage and environmental damage occurs

- South Pacific Regional Environment Programme – Pacific Ocean Pollution Prevention Program to identify WWII wrecks in SE Asia
- Small-scale Swedish risk assessment for wrecks in Skagerrak
- DE.E.P.P. project (DEvelopment of European guidelines for Potentially Polluting shipwrecks) to collect data in Mediterranean and to identify the Best Available Technologies for remediation and/or minimization of environmental risks
- US Wreck Oil Removal Project (WORP) – systematic wreck oil removal based on comprehensive scientifically-based, state-of-the-art risk assessments and cost-benefit analyses

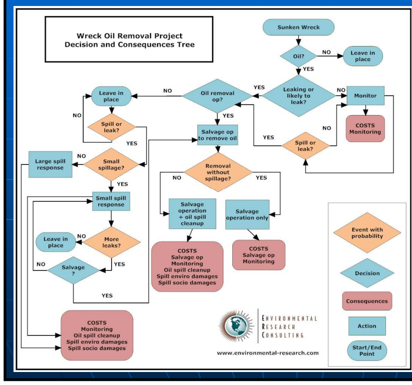
Comparing Strategies

- REACTIVE - Deal with continuous leaking or sudden release oiling events and damages as they occur – greater costs for spill response and damages, risk remains

OR

- PROACTIVE - Take proactive approach to remove oil from wrecks with greatest risk – highest potential for leakage or spillage and highest damages – lower costs, risk removed

Risk-Based Proactive Strategy



Identify wrecks with greatest potential for leakage or sudden oil release

Conduct risk analyses of impacts and costs of leaks and spills from wrecks

Compare costs/impacts of "leave alone" strategy vs. planned oil removal operations

Prioritize wrecks by risk

Remove oil from riskiest wrecks

Benefits of Risk-Based Approach

- Reduce threat of leaking oil from sunken wrecks
- Apply scientifically-based rationale for removal operations
- Reduce costs, damages, and environmental impacts
- Provide excellent training for response and salvage personnel
- Demonstrate state-of-the-art salvage and response strategies
- Cooperative effort between industry and governmental agencies

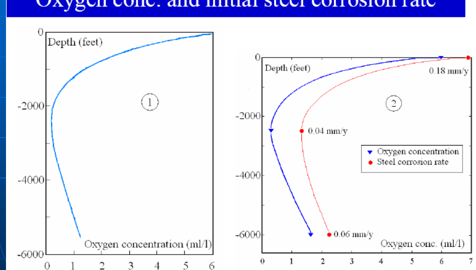
Risk = probability x impact

- Need to determine *probability* of leakage/spillage based on vessel type and condition, environmental factors - underwater/on-site surveys/engineering
- Need to determine *type* of leakage (chronic, episodic, massive release) - underwater/on-site surveys/engineering
- Need to determine probabilistic *impacts* for various scenarios - modeling

Determining Probability of Leakage

- On-site/underwater surveys to determine exact location, prevalent weather/current patterns, historical condition, water depth, physical condition and position, type of steel, effects of steel corrosion, site vulnerability, and tank inspection for remaining product.
- Preliminary desk study to determine vessel history and possible cargo/fuel contents
- Steel corrosion studies have shown rate of corrosion penetration to be approximately 0.064 – 0.074 mm/year, and field studies have shown even higher rates of up to 0.115 mm/year (Wrubel 2007).

Oxygen concentration as a function of depth
Oxygen conc. and initial steel corrosion rate



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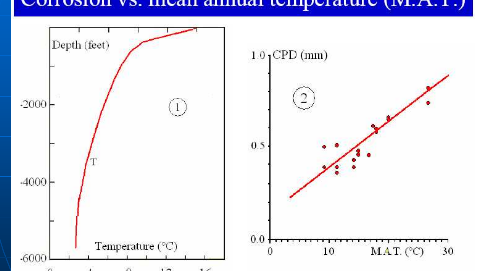
Temperature vs. seawater depth
Corrosion vs. mean annual temperature (M.A.T.)



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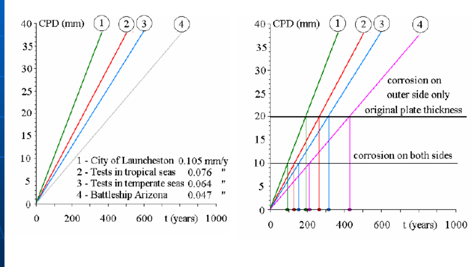
CPR experimental values and their use to forecast the complete corrosion of a 20 mm thick hull plate



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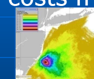
Modeling as Risk and Averted Cost Assessment Tool

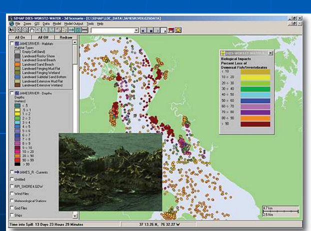
- Determine fate and impacts of potential spillage/leakage by scenario
- Quantify damages and costs from spill
  - Response costs
  - Environmental damages
  - Socioeconomic damages



- Simulate hypothetical spills for response planning or best timing of removal and environmental salvage operations
- Quantify averted damages from environmental salvage operations

SIMAP™ Modeling

Integrated Oil Spill Impact Model System
Applied Science Associates, Inc.

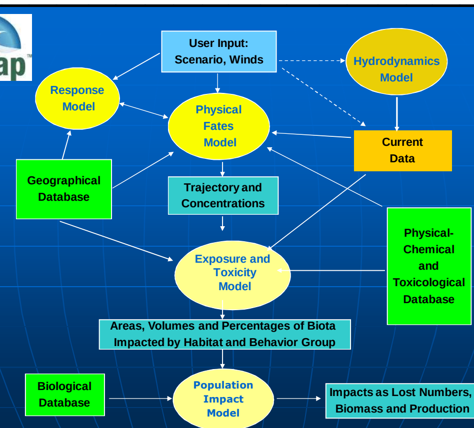


Three-dimensional simulation of oil behavior, transport, fate, and effects

Stochastic (probabilistic) scenario modeling

Spill response strategy modeling – dispersants, mechanical, burning

Coupled with ERC risk and cost modeling to provide complete state-of-the-art risk and cost-benefit modeling package

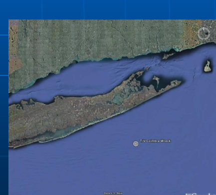


T/V Coimbra

423-foot British flag tanker attacked, torpedoed, and sunk by a German submarine on January 15, 1942

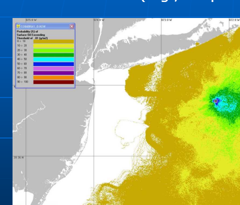
Resting in 180 feet of water 20 miles south of Long Island, New York

28,500 barrels (4,070 MT) of lubricating oil remain onboard in eight cargo tanks.

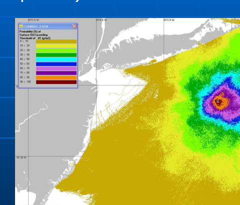


T/V Coimbra Hypothetical Spill Scenarios 4,070 MT of lube oil

Spread of oil dependent on wind, currents, and spill duration
Oil behavior (e.g., evaporation, dispersion) taken into account

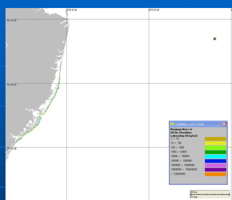


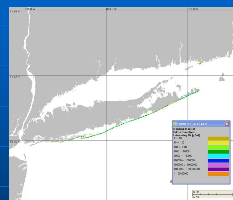
Probability of surface oil – four hour spill



Probability of surface oil – seven day spill

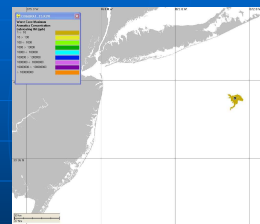
T/V Coimbra Shoreline Oiling



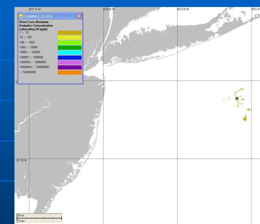


Winds *may* keep oil off shorelines, but, in worst case, if shoreline impact does occur, there could be considerable oiling of southern Long Island and New Jersey shoreline

T/V Coimbra Toxic Fish Impacts



Worst case aromatic concentration – four hour spill



Worst case aromatic concentration – seven day spill

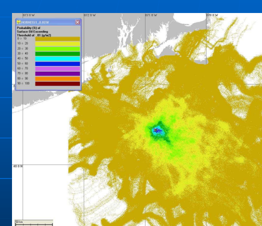
T/V Norness

489-foot Panamanian tanker attacked, torpedoed, and sunk by a German submarine on January 14, 1942

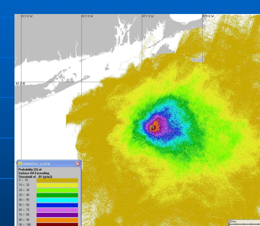
Resting in 270 feet of water 60 miles south of Montauk, Long Island, New York

107,000 barrels (15,285 MT) of No.6 fuel oil (heavy oil) remain onboard

T/V Norness Hypothetical Spill Scenarios 15,285 MT heavy No. 6 fuel oil

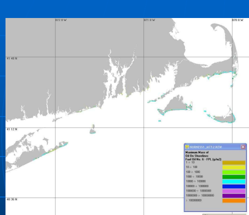


Probability of surface oil – four hour spill

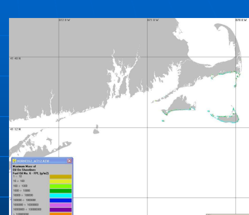


Probability of surface oil – seven day spill

T/V Norness Shoreline Oiling



Worst-case shoreline oiling– four hour spill



Worst-case shoreline oiling– seven day spill

Estimation of Environmental Salvage Operations Costs

- Highly dependent on water depth
- Situation-specific
- Costs can be controlled with pre-planning, project management, use of proven technologies, informed contracting, seasonal timing of operations

RANGE OF RELATIVE COSTS FOR RECOVERY (AVERAGE)

Relative Complexity	Impact factors on Cost	Cost range (M, USD)
Simple	Shallow depth (<20m) Low viscosity oil Protected water Local mobilization	<1-5
Moderate	Moderate depth (20-50m) Moderate viscosity oil Weather & sea restrictions Regional mobilization	2-7
Complex	Deep depth (50-250m) High viscosity Poor wreck condition Open water (limitations) Long mobilization	5-20+
Highly complex	Extreme depth (>250m) High viscosity Poor wreck condition Open water (limitations) Long mobilization	20-100+

Cost-Benefit Analysis

- Benefit of wreck oil removal operation = averted costs and damages
- Benefit should exceed cost of operation
- Immeasurable benefits need to be considered

Risk-based Approach

- Provides quantifiable measure of benefits
- Allows for prioritization of wrecks by quantifiable risk
- Provides powerful decision-making tool

TOOLS & TECHNIQUES

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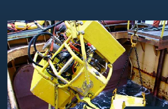
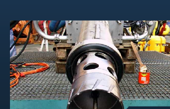
Cargo /bunker removal – intervention tools

- Hot tap
- Submersible hydraulic pumps
- ROV/remote operated pumping tools
- Special designed one-off equipment
- Heating/ water injection equipment
- Auxiliary equipment (non invasive)





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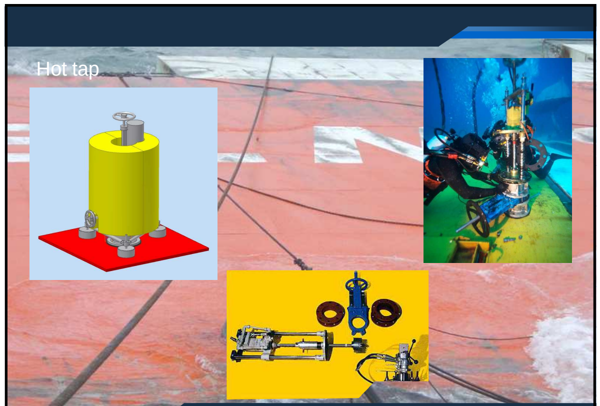
Hot tap



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SPECIAL TOOLING:
PIPE PENETRATION SAFETY VALVE
(PPSV)
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Remote operated offloading system (ROLS)
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Neutron back scattering device tested
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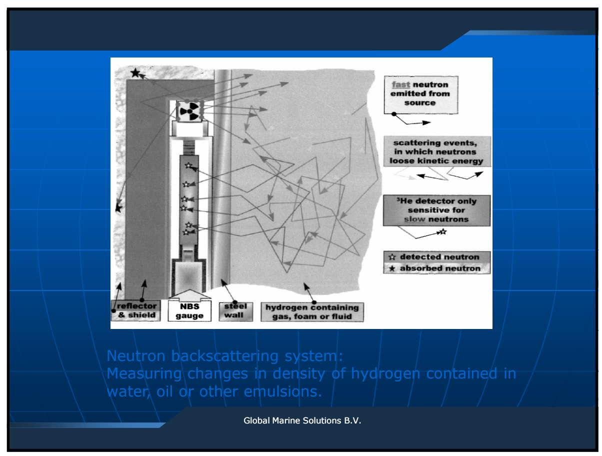
fast neutron emitted from source
scattering events, in which neutrons loose kinetic energy
³He detector only sensitive for slow neutrons
detected neutron
absorbed neutron
reflector & shield
NBS gauge
steel wall
hydrogen containing gas, foam or fluid
Neutron backscattering system:
Measuring changes in density of hydrogen contained in water, oil or other emulsions.
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Frame identification
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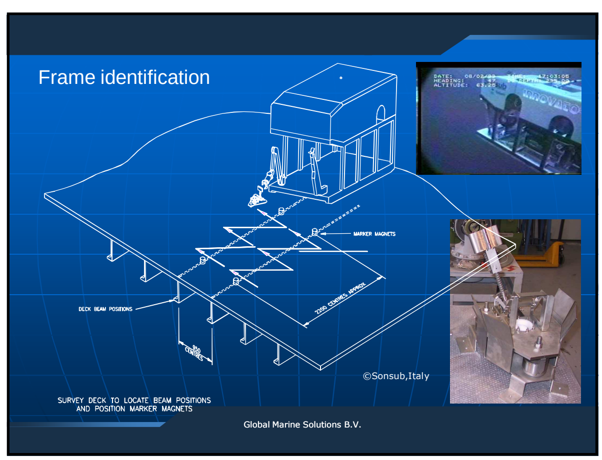
Frame identification
MARKER MAGNETS
DECK BEAM POSITIONS
SURVEY DECK TO LOCATE BEAM POSITIONS AND POSITION MARKER MAGNETS
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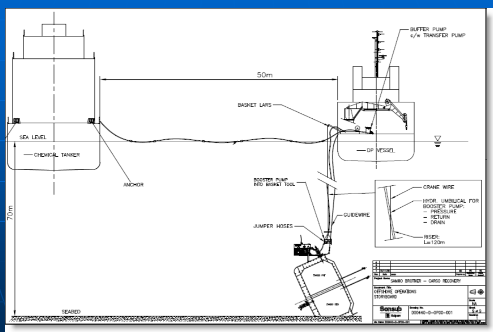
INTERVENTION METHODOLOGY:



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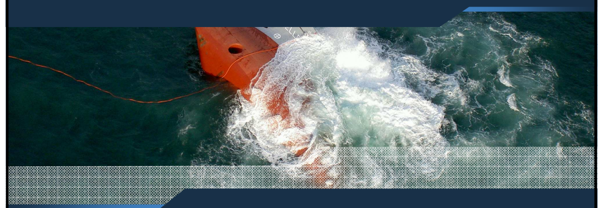

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